

Review of the manuscript „Hydrological response to warm and dry weather: do glaciers compensate?” submitted by Marit Van Tiel, Anne F. Van Loon, Jan Seibert, and Kerstin Stahl to Hydrology and Earth System Sciences (HESS)

Review by Mauro Fischer (Glaciologist at the Institute of Geography, University of Bern, Switzerland, mauro.fischer@giub.unibe.ch)

General comments

I want to thank the authors for their noticeably large amount of work for this very nice study and valuable scientific contribution. In my opinion, the study contains novel and highly interesting findings, the presented results seem solid overall (except maybe for how the authors calculated catchment-wide mass balance, see comments below) and are of high interest to the scientific community. In general, the manuscript is well written and very nicely illustrated (great figures!). I think that this work clearly deserves to get published in Hydrology and Earth System Sciences. The authors will need to put some effort into correction and improvement of their manuscript. In my opinion, there are still (even if only few) important major and a number of minor issues which need to be addressed, corrected, clarified, and implemented prior to publication. I guess that the majority of the specific comments listed below are easy to implement, whereas some general or specific comments will maybe need some additional work and time. I hope that my work for this review will help improving the paper, and I encourage the authors to implement and reply to all my comments as far as possible. Thanks a lot, it was a pleasure to review your study, congrats, all the best and kind regards.

List of some general comments:

- Abstract: very well written and very good overall! See some specific comments below. As you analyzed glacier-fed streamflow responses to WD in long-term streamflow observations (>50 years), in my opinion it would be beneficial for people interested in your paper to add some information about your observation periods for Canada, Norway, and the European Alps directly in the abstract as well...
- Introduction: I like the structure/storyline and content of the introduction, maybe it is a bit (too) long and could be shortened without losing important information and content? Sometimes I wondered whether the difference between “the buffering effect of glaciers” and “the compensation effect of glaciers” is always clear (or if there is any big difference at all...). Maybe you could check that point while going through the introduction (or the whole manuscript) again? Moreover, please find a number of specific comments which hopefully help to improve specific parts of the introduction below...
- Data: I have, unfortunately, some concerns about how you deal with and use measured mass balance data in your study; you cannot just take a median of measured glacier mass balance data, you have to weight the measured data with glacier area, i.e. calculate area-weighted average mass balances, otherwise you might get wrong results. This is relevant when it comes to compare or correlate mass balance with levels of compensation C , I clearly think you need to check and clarify that; moreover, it does

not really make sense to me to just use “country-wide” mass balance data for individual catchments you analyze, there are better ways to extrapolate measured mass balance data to individual catchments, especially in areas with a high density of measured mass balance data like Norway, Switzerland, Austria. Please see also specific comments thereupon below.

- Results: In section 4.2 you only refer to WD (or WWD) events, right (CD, and ND events are excluded)? Maybe make that clearer in the text (e.g. by changing the title of the section to “4.2 Glacier compensation during WD events in different catchments”); it was not very much clear to me why the chosen catchments and years for individual regions were selected for Figure 3 (just an example or do these three years and catchments reflect some of the “general observations, trends, and C values over the whole observation period”?)...
- Results: Section 4.4 and figure 9: As I understood how you calculate catchment-wide mass balance or take into account measured mass balance data to correlate it with levels of compensation C, in my opinion this is not quite correct (see comments above and specific comments thereupon below), maybe by correctly calculate catchment-wide mass balance your resulting correlations of mass balance with levels of compensation would quite change and show another relation between these variables?!...
- Results: Still section 4.4 and figure 10: To be honest, I didn't really understand how you calculated correlations between changes in C and glacier changes over time (mostly retreat for your period of observation, but with intermitten phases of readvance, for instance for Norwegian glaciers in the 1990s!), this is neither very clear from the methods section nor very clear in the results section... what data sets did you take into account to check if glaciers in the analyzed catchments did change in area and volume over your observation period? – this aspect, relating also to figure 10, is not very clear...
- In the whole manuscript: I think it would make more sense to use “southwestern Norway” instead of “Norway” and “western Canada” instead of “Canada” in the entire manuscript (these countries are so large and you analyze only catchments in specific regions)...

Specific comments and technical corrections

To facilitate the author's correction of the manuscript I combined specific comments and technical corrections (including language or spelling and comprehensibility issues). Sometimes comments contain both specific comments and technical corrections, sometimes just one or the other. I would ask the authors to implement my comments and suggestions as far as possible.

Title

Personally, I am also for short and concise, attractive titles (and I like yours), but maybe it would be good to add short information about your period of observation and study areas in the title? Up to you...

Abstract

Lns 11f: "C was, in general, higher than 100% for catchments with a higher relative glacier cover" → *is it possible to give a number of the (average) relative glacier cover (XY% of the catchment glacierized over the observation period) needed to result in a C ≥ 100%? Would be quite interesting...*

Ln14: "...which indicated the..." → *rather use present than past here as statement is still valid?*

Ln16: "...such as the snow fallen..." → *"...such as the amount of snow fallen..."*

Ln17: "Overall, these results suggest..." → *"Overall, our results suggest..."*

Lns17ff: *I know that you have to summarize and make short statements in the abstract, but, in my opinion, the last two sentences of the abstract could be a bit clearer and more precise (how do glaciers not compensate straightforwardly? What are "the different streamflow contributions and their variations" you refer to here?)*

Introduction

Ln 22: "...alter the input of hydrological systems..." → *"...alter the water input of hydrological systems..."?*

Ln 30: "In high mountain regions, where snow and ice are present, these snow and ice storages..." → *repetition of "snow and ice", maybe rephrase for smoother readability?*

Ln 31: "..., because of temperature-driven water supply." → *why not directly write what you refer to here? i.e. enhanced snow and ice melt due to high temperatures?...*

Ln 33: "...of catchments(e.g. Bakke..." → *insert space between "catchments" and "("*

Ln 34: "...also known to be a buffer against..." → *better: "...also known to act as a buffer against..."?*

Ln 34: "...these storages can also be themselves be depleted..." → *one "be" too much → "...these storages can also be depleted themselves..."*

Lns 42f: "Hence, groundwater and snow storages might not always be a perfect buffer during warm and dry periods." → *Please be a bit clearer and more precise here, I guess what you want to say here is something like "Hence, groundwater only has a limited buffering capacity*

(in terms of runoff, provides only baseflow), while the buffering capacity of snow is higher (in terms of additional runoff) but temporally limited (if all snow has melted, there is no buffer anymore).

Ln 44f: "...a favorable buffer during such periods..." → *"...a favorable buffer during warm and dry periods..."*

Ln 46: "...in the year..." → *"...throughout the year..."?*

Ln 48f: "During such extreme drought years..." → *why "such"?*

Ln 49: "...runoff from glacier areas..." → *"...runoff from melting glaciers..."?*

Ln 49: "...55-100% of summer runoff..." → *"...55-100% to summer runoff..."?*

Ln 55: "...from other streamflow contributions such as snowmelt." → *maybe add some additional important streamflow contributing processes (in high mountain areas) here → "...from other streamflow contributions such as snowmelt, surface runoff, interflow, groundwater flow or melting permafrost."?!?!*

Ln 58: "...during such extreme warm and dry periods." → *why "such"?*

Ln 60ff: "During warm and dry years, glaciers can provide more meltwater to streamflow, and during cold and wet years they generate less meltwater so that altogether the interannual streamflow variability is relatively low." → *do the studies you refer to here give a "lower threshold ratio of glacierization" for individual catchments (i.e. minimum percentage of glacier-covered area in a catchment) from which the dampening effect of glaciers on interannual streamflow variability applies? – would be interesting added value here...*

Ln 64: "The result of the balancing between melt and precipitation is assumed..." → *In order to be clearer, I'd rather write "Whether the amount of runoff from melting glaciers has a dampening effect on the interannual streamflow variability or not is assumed..."*

Ln 66f: "...but also other climate and catchment characteristics appear to influence the streamflow sensitivity to climatic anomalies..." → *other climate and catchment characteristics like what? – can you give some examples mentioned in the studies you refer to here?*

Ln 69: "...mountain glaciers have been retreating..." → *"...mountain glaciers around the globe have been retreating..."*

Ln 72: "...provided an additional source of water in the summer compared to the seasonally delayed contribution." → *why "COMPARED TO the seasonally delayed contribution"? rephrase in order to be clearer...*

Ln 73: "However, this source will not be sustained" → *"However, additional meltwater from shrinking glaciers will not be sustained forever."*

Ln 74: "...some regions..." → *"...some glacierized mountain areas..."*

Ln 78: "...differs in different catchments..." → "...varies for different catchments..."

Ln 80: "...than low glacierized catchments." → "...than catchments with low relative glacier cover".

Lns 80ff: "However, this contribution may reach a maximum, as the higher glacierized catchments are generally located at higher elevations that receive more orographic precipitation amounts..." → *can you please check that statement? In my opinion, it is not primarily the increased amounts of precipitation that causes a maximum value of relative catchment glacier cover in terms of increased streamflow contribution by glacier melt, but rather air temperature and climatic conditions in highly glacierized catchments, isn't it?*

Ln 83: "...is generally assumed to be highest in August and September, ..." → *of course, this is only true for mountain glaciers in the northern hemisphere with a mass balance regime similar to the one in the Alps... I am sure you are aware of that but it might be good to be more precise here... (as your study is interesting to people from all over the world ;-)*

Ln 85: "...relative contribution is, ..." → "...relative glacier melt contribution is, ..."

Ln 96: "This scale enables..." → "The chosen time scale enables...?"

Ln 97: "Moreover, this scale..." → "Moreover, this time scale..."

Lns 99f: "...we analyzed observed hydrological responses to WD events for catchments with varying glacier cover in Norway, Canada, Switzerland and Austria." → *I recommend to add some information about the observation periods / temporal time frame of your study here.*

Data and hydroclimatology of selected glacierized catchments

Ln 108: "...based on length of the time series (long records), ..." → "...based on the length of available data time series (long records), ..."

Ln 109: "...missing values..." → "...data gaps..."

Ln 109: "... (including low and high glacierized catchments) ..." → "... (including catchments of low to high relative glacier cover) ..."

Lns 109f: "A few of these catchments are nested." → *What does this exactly mean here? – Can you maybe briefly explain in key words in parentheses after the sentence?*

Ln 110: "...derived from gridded data products..." → "...derived from gridded reanalysis data...?"

Ln 115: "...for the different catchments differed, between 50 and 68 years." → "...for the different catchments varied between 50 and 68 years."

Ln 118: "...but the selection of events..." → "...but the selection of WD events...?"

Ln 119: "...occurred mostly in the winter months." → "...coincide mostly with the winter months."

Lns 122f: "Therefore, regional average mass balance time series were calculated from all available mass balance observations per year per country (Austria, Switzerland, Norway and Canada) by taking the median." → *If I understood your approach right, then, as a glaciologist, I have some concerns here:*

1) *Taking just an average or median value from measured mass balance data of individual glaciers is not really correct, you need to calculate area-weighted average mass balance values (as for instance large valley glaciers have their ablation area at lower elevation (therefore more melt, therefore more negative mass balance) compared to smaller mountain glaciers having their terminus at higher elevation (therefore less melt, therefore less negative mass balance)); i.e. you have to multiply all mass balance data you take into account by glacier area, then calculate the sum of these values for all glaciers, and finally divide that sum by the summed up glacier areas*

2) *Even though for instance Switzerland and Austria are small countries, measured in-situ mass balance sometimes comes from glaciers with significantly different regional climatic conditions (the same must apply for Canada, for Norway your catchment sample lies in a more or less similar climatic zone I guess)... So my point here is that, in my opinion, it does not make sense to calculate average mass balance values "by country" for the catchments you analyze! For example, Schaeffli et al. (2019, The role of glacier retreat for Swiss hydropower production, Renewable Energy) calculated area-weighted mass balance data for all glacier-covered catchments with hydropower plants using data by Fischer et al. (2015, Surface elevation and mass changes for all Swiss glaciers 1980-2010, The Cryosphere). I think you should find a way to reasonably derive catchment-wide mean annual mass balance data from existing measured mass balance data and extrapolation techniques (for the latter see for instance Huss (2012), Extrapolating glacier mass balance to the mountain-range scale: the European Alps 1900–2100, The Cryosphere); you might also work with Huss and Hock (2015, A new model for global glacier change and sea-level rise, Frontiers in Earth Science, there, past and future glacier mass balance data is available (per glacier!) from the Global Glacier Evolution Model (GloGEM)). Whatever data you use or method you apply to extrapolate (measured) mass balance data to glaciers of your analyzed catchments, do not forget that you have to calculate area-weighted values again if you have to work with "catchment-wide" mass balance data for your analyses. If you want you can also contact me personally (mauro.fischer@giub.unibe.ch) and I would be happy to discuss that with you and try to help you there.*

Ln 128: "...(GI4, 2015)..." → *I think you need to add the correct reference for the Austrian glacier inventory used here.*

Ln 130: "...Randolph glacier inventory (RGI) for Canada..." → *maybe add the version of the RGI you worked with (as there were a lot of updates from the first to the latest RGI version)...*

Ln 128: "...ranging in size from..." → *rather put the "in size" at the end of the sentence (after the numbers)*

Ln 174: *I would delete the "(not shown)" here... but would it maybe make sense to add a table with catchment name, location, size, mean elevation, mean annual temperature, mean annual precipitation and resulting levels of compensation to the Supplementary Materials? – This would add some relevant detail for people interested in catchments you looked at...*

Methods

Ln 181: "WD spells..." → "WD periods..."?

Ln 188: "...e.g. van Loon, 2015))" → *Delete one of the parentheses there*

Ln 202: "Once the periods..." → "Once the WD (or other dry event) periods..."?

Lns 202ff: "It was assumed that in these high elevation catchments there is an immediate response to the WD events (or the other dry events) and streamflow data of the dates exactly corresponding to the events were selected." → *can you add some information on why (from a process understanding point of view) it is ok to work with that assumption? I argue that you're right with this assumption but giving some rationale here would be good I think.*

Ln 208: "...Q_n..." → "...Q_n...", also everywhere else in the text?

Ln 216: "C of the events..." → "Resulting C values of the events..."?

Ln 219: "...general trend of streamflow during the event." → "...general trend of streamflow behavior during the event."?

Lns 227f: "...the importance of different event drivers." → *as for example?*

Lns 228f: "glacier cover" → "relative glacier cover" (twice)

Ln 231: "...at least 8 or more events..." → *what is your rationale behind this threshold?*

Results

Ln 235: "... (Table 3." → "... (Table 3)."?

Lns 240f: "...and different numbers of catchments per region." → *I would also argue that they are not comparable due to different (hydro-)climatological settings of the individual catchments!?*

Ln 242: "...occurred in the year 1982..." → "...occurred in 1982..."

Ln 250: *I would delete both commas there...*

Ln 257: "...the importance of glacier cover..." → "...the importance of relative glacier cover..."

Ln 260: *add a comma before "too."*

Ln 262: "...for the two lower gc catchments..." → "...for the two catchments with lower gc..."

Ln 263: *I would delete the "pushed"*

Ln 265: *"...compared to the regime..." → "compared to the long-term daily streamflow regime..."*

Ln 270: *"...part of the variance of C..." → "...part of the variance in C..."*

Ln 275: *"...below the normal regime..." → "...below the long-term daily streamflow regime..."*

Ln 279: *"The spread in responses..." → "The variability in streamflow responses..."*

Ln 287: *"The streamflow responses of WWD and WD events..." → "The streamflow responses to WWD and WD events..."*

Ln 291: *"...were below the normal regime..." → "...were below the normal streamflow regime..."?*

Lns 295f: *"Different rainfall amounts..."; "...high rain amounts in summer..."; "...low rain amounts in summer..." → I guess you refer to the climatological statistics here (how much rain falls on average in one region in summer, cf. figure 2)... I would write that somehow in this sentence in order to be clear...*

Ln 297: *I think you can delete the comma there...*

Ln 298: *"Having less rainfall..." → "Less rainfall..."?*

Lns 300f: *"Also, the relative glacier covers of the Canadian and Alps catchments are more complementary than comparable in this sample of catchments." → I believe to see your point here, but doesn't make this statement figure 7 and your rationale/descriptions here about the influence of the amount of average summer rainfall on the levels of compensation a bit obsolete?...*

Ln 304: *"...show these sometimes rather large ranges. To explain these ranges,..." → "...show this sometimes large variability in catchment-wide C. To explain this variability,..."*

Ln 306: *"...variance of C..." → "...variance in C..."*

Lns 323f: *"...when MB_{sum} is larger (more negative)." → "...when MB_{sum} is more negative." → as I wrote above, try to avoid speaking of larger/higher and smaller/lower mass balance, this is always confusing (use "more negative" and "more positive")...*

Lns 328f: *"Most significant trends were found in June (Canada) and September (European Alps), which were all negative. Norwegian catchments showed mostly positive trends, except in September." → ok, what does that mean? Can you maybe relate these correlations to observed glacier changes in the analyzed catchments? For Switzerland, see for instance M. Fischer et al. 2014 (The new Swiss glacier Inventory SGI2010, Arcitic, Antarctic and Alpine Research, section Study Region), for Austria, see for instance A. Fischer et al. 2015 (Tracing glacier changes in Austria from the Little Ice Age to the present using a lidar-based high-resolution glacier inventory in Austria, The Cryosphere), for Norway see for instance*

Winsvold et al. 2014 (*Glacier area and length changes in Norway from repeat inventories, The Cryosphere*), for western Canada see for instance Bolch et al. 2010 (*Landsat-based inventory of glaciers in western Canada, 1985-2005, Remote sensing of Environment*)...

Discussion

Ln 334: *why “such”?*

Ln 340: “...daily regime...” → “...*daily streamflow regime*...”?

Ln 341: “...during such an event...” → “...*during a WD event*...”?

Ln 346: “...as in these rapidly changing systems...” → “...*as it concerns rapidly changing systems*...”?

Ln 346: “...daily regime...” → “...*daily streamflow regime*...”?

Ln 350: “...high summer.” → “...*midsummer*.”?

Ln 351: “...such events...” → “...*WD events*...”?

Ln 351: “...in the summer shoulder season...” → “...*in midsummer*...”?

Ln 354: “Glacier cover...” → “*Relative glacier cover*...”?

Ln 360: “...for events...” → “...*for WD events*...”?

Lns 366f: “But Figure 4 shows that there are exceptions.” → *I guess you refer to catchments and C values in Canada here? – Thus, exceptions concern catchments in drier average summer climates (cf. Figure 2) with already low relative glacier cover? → be more concrete/precise here...*

Ln 370: *Is there a comma lacking after the parentheses?*

Ln 371: *Is there a comma lacking after “conditions”?*

Ln 372: “...also make it difficult to answer when glaciers compensate because it depends on the situation.” → *a bit vague and not very clear to me, can you rephrase in order to be more precise here?*

Ln 373: “...these variations...” → “...*this variability*...”?

Ln 376: *Why do you refer to Figure 11 here? – Shouldn't you refer to figure 8?*

Ln 382: “...was influencing...” → “...*is influencing*...”?

Ln 383: “...above 2000 m elevation...” → “...*above 2000 m a.s.l.*...”?

Ln 384: "...became less clear..." → "...is less clear...?"

Ln 388: "(more snow more recharge, higher spring temperatures less recharge because of saturation)" → "(more snow - more recharge, higher spring temperatures - less recharge because of saturation)", be consistent with Lns 386, 387...

Ln 390: "...MAM temperature anomalies..." → "...spring temperature anomalies...?" or is it clear for anyone that "MAM" refers to March, April, May?

Ln 392: Can you shortly explain in parentheses what "carry-over storage" exactly means?

Ln 394: "...was found to be..." → "...is..."

Ln 399: "In the first explanation..." → "In the former case...?"

Ln 400: Why do you refer to Figure 11 here? – Shouldn't you refer to figure 8?

Ln 400: "...in the second explanation..." → "...in the latter case...?"

Lns 402f: "...in high elevated catchments..." → "...in high mountain catchments...?"

Ln 409: "...Mackay et al. (2020); Somers et al. (2019); Somers and McKenzie (2020)..." → "(Mackay et al., 2020; Somers et al., 2019; Somers and McKenzie, 2020)"

Ln 413: There is a reference lacking here I guess...

Lns 418f: "Also, increasing high temperatures or more often occurring relatively extreme temperatures will not be sustained with higher melt contributions when glaciers retreat." → this is only true for time periods after "peak water" of individual catchments, I am sure you know that, but maybe you could include that in some way in your statement here...

Ln 421: "...400 mm higher." → I am not sure how I can interpret this value, is it per m² (for the entire catchment)? Add some information here...

Lns 422f: "This may relate to the shorter durations of WWD events and the overall high event responses in June..." → add "...due to enhanced contribution from snowmelt compared to the later summer season..." in parentheses after "in June"?

Ln 432: "...may become..." → "...becomes..." (as, at least for temperate glaciers, this is always the case in summer)

Ln 438: "...changes over time." → "...changes in streamflow response to WD events over time."?

Ln 439: "...trends of C over time..." → "...trends in C over time..."

Ln 447: "...decreasing trends with time..." → "...decreasing trends in C with time...?"

Ln 448: I would delete the comma here; add "in future" after "...will change...?"

Ln 445: *I would delete "in the world"*

Ln 446: *I think here it becomes obvious that it would make sense to talk/write about "southwestern Norway" and "western Canada" in the entire manuscript (because you clearly make a statement about southwestern Norway and not the entire glacierized catchments of Norway here... (see also general comment thereupon above)...*

Ln 464: *"...Canada and European Alps..." → "...Canada and the European Alps..."*

Ln 484f: *"...and is then not related..." → "...which is then not related..." (as you refer to streamflow and not to high precipitation amounts before a WD event here...*

Ln 489f: *"To shorten the streamflow event responses..." → "To shorten the analyzed time frame of streamflow responses to WD events..."*

Ln 492: *"...shortening them..." → "...shortening the analyzed time frame..."*

Ln 494: *"...grid product..." → "...gridded product..."?*

Ln 495f: *"...(and thus higher temperatures)..." → "...(with thus higher temperatures)..."?*

Ln 497: *"...melt temperatures..." → "...melting conditions..."*

Ln 500: *"...during these events..." → "...during WD events..."*

Ln 500f: *"...during this time of the year..." → "...during the summer months..."*

Ln 504f: *"Higher temporal resolution measurements of glacier mass balances..." → "Measurements of glacier mass balances with higher temporal resolution..."*

Ln 509: *"...melt-out date of..." → "...disappearance date of..."?*

Ln 511: *I would delete the comma here*

Ln 513: *"...there is quite a risk of internal model compensation..." → can you add some information here (maybe in parentheses)? What does that actually mean? What exactly do you refer to here?*

Ln 514: *"...van Tiel et al.(2020b)..." → "...(van Tiel et al., 2020b)..."*

Ln 516: *add a comma before "too."*

Conclusions

Ln 521: *"...in Norway..." → "...in southwestern Norway..."*

Ln 532: *"Besides these variations..." → "Besides the variability..."?*

Ln 534: "...with levels..." → "...with compensation levels..."

Ln 535: "...streamflow anomalies 30 days before the event..." → "...streamflow anomalies during 30 days before the event..."

Ln 538: "Understanding these different mechanisms..." → "Understanding the different mechanisms..."

Ln 541: Delete "these"

Ln 543: I would add "in high mountain catchments" before "over the summer"

Figures

Figure 1: Maybe add scales to a), b), c). I would write "Norway" (in green), "European Alps" (in blue), and "Western Canada" (in pink) at the lower right of the figure 1d). Moreover, can you add a more detailed legend for the circle sizes which signify the relative glacier cover of a catchment (i.e. how much relative glacier cover do the different circle sizes in 1d) represent?). Moreover, would it possibly make sense to additionally draw areas with "similar hydroclimatological regimes" (cf. chapter 2.3) in Fig. 1? – Maybe this would add valuable graphical information...

Figure 2: Looking at figure 2 I cannot really understand why two different graphs for Norway, four different graphs for Canada, and three different graphs for the European Alps. Can you please add something on that in the figure caption? You explain it in chapter 2.3 but I think to add some information thereupon in key words would be good for the figure caption.

Figure 3: You have to add a bit of information in the figure caption there: Write what exactly the i) black line, ii) blue line, and iii) the red dots signify (I know it's written in abbreviations at the bottom of the graph but it would be helpful to have that information (as text) in the figure caption as well). The same for the relative glacier cover (bold black number in the upper right corners), write it as text in the figure caption as well to be clear. Can you please also add somewhere in the manuscript (text or figures) based on what you chose to show the selected results for some selected catchments and selected individual years for the three regions (shown in Figure 3)? What was your rationale behind that? And maybe also which catchments (names, location) are shown?

Figure 4: Figure caption: Write "Mean catchment level of compensation..." as in the figure caption of Figure 6!?!; "...indicate the mean response..." → "...indicate the mean streamflow response..."?

Figure 5: Figure caption: "...during the WD in different regions..." → "...during the WD events in different regions..."

Figure 6: Figure caption: maybe add "...in different regions (rows) and months (columns) at the end of the first sentence to be consistent with figures 4 & 5?!; "If all dry periods occurred..." → "If all dry periods occurred at the same time..."?

Figure 7: *Figure caption: "...that have low summer rain..." → "...with low average summer rain amounts..."; "...and high summer rain amounts..." → "...and high average summer rain amounts..."; maybe add again information about what the pink and blue bars mean (see e.g. figure caption of figure 5)...*

Figure 8: *Figure caption: "Explained variance of C..." → "Explained variance in C..."; moreover, neither from the figure nor from the text it is evident how the thresholds to separate individual classes of relative glacier cover were chosen... can you add some information on that please?*

Figure 9: *Figure caption: Delete the "9" at the beginning of the figure caption; you would have to write out the used abbreviations for annual, winter and summer mass balance somewhere (I would argue better in the text than here in the figure caption, for MB_{win} you did it in the text); "Colours and symbols indicate the three regions (as in other figures)." → why not be concrete and directly write colours of symbols together with corresponding regions here; can you explain the " r_s " (y-axes)? I would just add (r_s) in the figure caption in parentheses after "Spearman rank correlation"...*

Figure 10: *Figure caption: I would again write colours of symbols together with corresponding regions here; moreover, it is not really clear to me how time trends of C were related to time trends of relative glacier cover here (see general comments thereupon above...), I would need some more information in the figure caption to know how to exactly interpret this figure...*

Figure 11: *Figure caption: I would delete the "the deficit" at the end of the figure caption; am I right that this conceptual figure is only valid for the situation during summer season? – I would add that in the figure caption...; would it not be less misleading if you write "Q (high gc)" and "Q (low gc)" in the figure rather than "Q (>>gc)" and "Q (<<gc)"?...*

Tables

Table 1: *Add full stop at the end of the table caption.*

Table 2: *Table caption: "...level of compensation. (C)" → "...level of compensation (C)."; "Higher elevated glaciers:..." → "Glaciers at higher elevation:..."; "Percentile of mean temperature in spring (MAM)" → which percentile?; "Percentile of sum of precipitation in winter (DJF)" → which percentile?; "The streamflow percentile of the 30 days before the WD event" → which percentile?; "Higher MB_{sum} ..." → I would delete that because "higher" means more positive and here you mean more negative (it is always easier to talk about "more negative" or "more positive" glacier mass balances in order to avoid misunderstandings when using "higher" or "lower" mass balances!), moreover you use the abbreviations MB_{sum} and MB_{win} but don't explain them (I can easily guess what it means but someone else not too familiar with glaciers might not at first glance); please see also my comments above about how you calculated "regional mass balances", I think if you calculate catchment-wide mass balance or mass balance anomalies in a more appropriate/more correct way you can use these numbers much better for a more realistic interpretation of "C" with the help of mass balance data...*

Table 3: *Table caption: “in brackets” → “in parentheses”; Add full stop at the end of the table caption; “Years most events” → “Years with most events”; in my opinion it would be good to add the actual observation periods (e.g. 19XY-19XY) in parentheses after “Alps”, “Norway” and “Canada”!*

Table 4: *Table caption: “The numbers in between brackets...” → “The numbers in parentheses...”; in my opinion it would be good to add the actual observation periods (e.g. 19XY-19XY) in parentheses after “Alps”, “Norway” and “Canada”!*